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Short-term Revision Risk of Patellofemoral Arthroplasty Is High: An Analysis from Eight Large Arthroplasty Registries

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Abstract

Background Patellofemoral arthroplasty (PFA) is one option for the treatment of isolated patellofemoral osteoarthritis, but there are limited data regarding the procedure and results. Because isolated patellofemoral arthritis is relatively uncommon, available case series generally are small, and even within national registries, sample sizes are limited. Combining data from multiple registries may aid in assessing worldwide PFA usage and survivorship.

Questions/purposes We combined and compared data from multiple large arthroplasty registries worldwide to

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Wolters Kluwer

ask: (1) What proportion of patients undergoing primary knee arthroplasty have PFA? (2) What are the patient and prosthesis characteristics associated with PFA in common practice, as reflected in registries? (3) What is the survivorship free from revision of PFA and what are the reasons for and types of revisions?

Methods Data were provided by eight registries that are members of the International Society of Arthroplasty Registries (ISAR) who agreed to share aggregate data: Australia, New Zealand, Canada, Sweden, Finland, Norway, the Netherlands, and the United States. De-identified data were obtained for PFA performed from either the beginning of year 2000, or the earliest recorded implantation date after that in each individual registry when PFA data collection commenced, up to December 31, 2016. This included patient demographics, implant use, all-cause revision rate (determined by cumulative percent revision [CPR]), and reasons for and type of revision.

Results During the data collection period, 6784 PFAs were performed in the eight countries. PFAs comprised less than 1% of primary knee replacements in all registries. Patient demographics were comparable in all countries. Patients were generally more likely to be women than men, and the mean age ranged from 50 years to 60 years. All registries showed a high rate of revision for PFA. The 5-year CPR for any reason ranged from 8.0% (95% CI 4.5 to 11.5) in Norway to 18.1% (95% CI 15.5 to 20.7) in the Netherlands. The most common reason for revision across all countries was disease progression (42%, 434 of 1034). Most PFAs (83%, 810 of 980) were revised to a TKA.

Conclusions The revision risk of PFA in all registries surveyed was more than three times higher than the reported revision risk of TKA at the same times. The survivorship of PFA is similar to that of the no-longer-used procedure of metal-on-metal conventional hip replacement. Although there may be potential functional benefits from PFA, these findings of consistent and alarmingly high rates of revision should create concern, particularly as this procedure is often used in younger patients.

Level of Evidence Level III, therapeutic study.

Introduction

Isolated patellofemoral osteoarthritis may cause substantial knee pain and loss of function. Although isolated patellofemoral osteoarthritis is an uncommon form of knee osteoarthritis, when severe painful arthritis is present, joint arthroplasty may be recommended [13, 17, 18]. TKA has predictable, durable, and generally good results [19, 24, 26], while patellofemoral arthroplasty (PFA) has been promoted as a more bone- and soft-tissue preserving option and is also reported to produce good-to-excellent outcomes in selected patients [15, 39, 41, 43].

Although PFA has been reported to have the potential for improved recovery, biomechanics, and function compared with TKA, concerns about high revision rates persist [9, 39]. First-generation PFA involved isolated patella resurfacing, while second-generation implants included narrow and short trochlea inlay implants that were somewhat limited in their ability to accommodate the native anatomy [41]. Although first- and second-generation prostheses did not provide consistent results, these have now largely been replaced by third-generation anterior-cut onlay implants that appear to have a more anatomic design, which may result in better function and survivorship [22, 41].

Because of the infrequency of the procedure, data on the use of PFA are limited to a small number of published series reporting short- to mid-term follow-up [1, 2, 9, 25, 44]. Even registry data are also limited by size, particularly with regard to prosthesis-specific results and reasons for revision [31]. As a result of these problems, a systematic review approach has been used, combining registry data with clinical studies [6, 44]. However, this approach included studies of older-style prostheses, and only included data from three selected registries (UK, New Zealand, and Australia) and, therefore, may not represent worldwide current practice.

Combining data from registries has been helpful when studying infrequent occurrences, such as the outcome of hip arthroplasty in patients younger than 22 years of age or the risk of re-revision with tantalum acetabular implants [14, 18].

Each author certifies that neither he or she, nor any member of his or her immediate family, has funding or commercial associations (consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

Each author certifies that his or her institution approved the reporting of this investigation and that all investigations were conducted in conformity with ethical principles of research.

This work was performed at Australian Orthopaedic Association National Joint Replacement Registry, based at the South Australian Health and Medical Research Institute, Adelaide, South Australia.

We combined and compared data from multiple national and regional arthroplasty registries worldwide to ask: (1) What proportion of patients undergoing primary knee replacement have PFA? (2) What are the patient and prosthesis characteristics associated with PFA in common practice, as reflected in registries? (3) What is the survivorship free from revision for any cause of PFA and what are the reasons for and types of revisions?

Patients and Methods

Data were provided by seven large national, and one insurance-based arthroplasty registries that report PFA and their revision procedures, and who consented to contribute aggregate data for the purpose of this analysis. These included the Australian Orthopaedic Association National Joint Replacement Registry, the New Zealand Joint Registry, the Canadian Joint Replacement Registry, the Swedish Knee Arthroplasty Register, the Finnish Arthroplasty Register, the Norwegian Arthroplasty Register, the Dutch Arthroplasty Register, and the Kaiser Permanente Total Joint Replacement Registry in the United States. All registries involved in this study have achieved quality standards enabling membership in the International Society of Arthroplasty Registries (ISAR) [16] and share a common aim to improve the outcomes of individuals undergoing joint replacements. De-identified aggregate-level data were requested for all knee arthroplasty procedures performed from January 1, 2000 or the date of first recorded PFA up to December 31, 2016. The Australian Orthopaedic Association National Joint Replacement Registry, New Zealand Joint Registry, Norwegian Arthroplasty Register, and Swedish Knee Arthroplasty Register provided data from 2000. Kaiser Permanente provided data from 2002, the Finnish Arthroplasty Register provided data from 2006, the Dutch Arthroplasty Register provided data from 2007, and the Canadian Joint Replacement Registry provided data from 2012.

The responding registries have data completeness of 95% to 99% for primary knee and more than 85% for revision procedures [4, 10, 11, 29, 33, 36, 47] with the exception of Canada, where the capture rate is 72% due to the voluntary nature of data contribution in some provinces [7]. Although the completeness of Canadian data may be lower, this would be likely to affect this country's PFA, TKA and revision knee arthroplasty data equally, and because this registry only contributed 6% (431 of 6784) of the PFA procedures for the total analysis, the potential for any missing data to affect the overall results would be minimal. Although the participating registries differ in some ways, such as being national or insurance-based, our intention was to compare these registries to find similarities and differences in knee surgical practice.

Registries were initially contacted between May 2017 and June 2017 to confirm their willingness to participate. Between September 1, 2017 and February 1, 2018, registries provided the requested summary-level data electronically, which included patient demographics (age, sex, BMI, and operative side), prostheses used, number of revisions for all causes, reason for revision, and type of revision. Revision was defined as a reoperation of a previous knee arthroplasty where one or more components were removed, replaced, or added. Data received enabled maximum follow-up periods of 5 years for the Canadian cohort, 9 years for those from the Netherlands, 10 years for Finnish patients, 15 years for the Kaiser-Permanente group, and 17 years for those from Australia, New Zealand, Norway, and Sweden.

Statistical Analysis

Frequencies, proportions, means, and SDs were used to describe each registry's cohort. All descriptive analyses were completed by each participating registry to protect individual patient information, and summary-level information was provided to the coordinating registry (Australian Orthopaedic Association National Joint Replacement Registry) for aggregation. All analyses were performed using SAS (Statistical Analysis System), version 9.4 (SAS Institute Inc, Cary, NC, USA) [40]. Participating registries were provided with SAS code so that they could obtain Kaplan-Meier estimates of survivorship. The Kaplan-Meier method was chosen because not only is it the standard method for registry data analysis, but also in this patient group the competing risk of death is low. These were then used to calculate the cumulative percent revision (CPR), which is the complement (in probability) of the Kaplan-Meier survivorship for each year of follow-up. The CPR 95% CIs were also calculated. The proportion of knee replacements that were PFA were calculated for each country for each year. We had also intended to perform prosthesis comparisons by manufacturer and type but found that the differing data formats and detail regarding revision timing was insufficient for this type of analysis.

Results

Usage of Patellofemoral Arthroplasty

As a proportion, PFA comprised 0.45% of all knee replacements in the recorded registries during the study period. A total of 6784 PFA procedures were recorded, during which time 1,492,950 knee replacements were performed. The use of PFA was small in all countries, ranging from 0.066% in Finland (76 of 114,814 knee replacements) to 0.64% in the Netherlands (1234 of 191,487 knee

replacements). The yearly proportions of PFA remained less than 1% in all countries during the study period, with the exception of Norway for the year 2016 only (Fig. 1). The annual number of PFA procedures increased across the registries over time, particularly for Australia, Norway, and Canada (Table 1). PFA as a proportion of all knee arthroplasties increased only slightly for Norway, Finland, Kaiser Permanente and New Zealand, while staying constant in Australia, Canada, Sweden and the Netherlands (Fig. 1).

Patient and Prosthesis Characteristics Associated with PFA

The mean age of patients ranged from 50 years in Finland to 60 years in Australia, and 76% of the 6784 patients were women, ranging from 62% (47 of 76) in Finland to 79% (341 of 431) in Canada. Where BMI data were available (Australia, Kaiser Permanente, Sweden, Finland, and the Netherlands), the pre-obese category (BMI of 25 kg/m^2 to 29.9 kg/m^2) was the most common group in all five countries with 39% (644 of the 1662 with BMI data) (see Supplemental Table 1, http://links.lww.com/CORR/A337).

Most (95%) PFAs were performed because of osteoarthritis (6419 of 6854 with a recorded diagnosis); fracture was the primary diagnosis in 1.6% (112 of 6854). Rheumatoid or "other inflammatory" arthritis was the primary diagnosis in 0.6% (44 of 6854) of procedures, and osteonecrosis was recorded for three PFAs. The primary diagnosis was given as "other" or unrecorded in 2.4% (165 of 6854) procedures. Diagnosis data was missing in one procedure from Sweden, 57 from Norway, and 21 from the Netherlands. In New Zealand and Norway, more than one primary diagnosis may have been provided for each procedure (see Supplemental Table 2, http://links.lww.com/CORR/A338).

PFA prosthesis details were available for 90% (6192 of 6854) of procedures. Of these, 97% (6006 of 6192) were a third-generation design. The Gender Solutions® (Zimmer Inc, Warsaw, IN, USA) was the most commonly used prosthesis across most registries (New Zealand, Kaiser Permanente, Sweden, and the Netherlands) but the proportional use of this prosthesis varied between countries (Fig. 2). The Avon™ (Stryker, Kalamazoo, MI, USA) and Journey™ (Smith and Nephew, Memphis, TN, USA) were the most commonly used prostheses in Finland and Norway, respectively. In Australia, the Avon and Gender Solutions were equally the most commonly used prostheses. No prosthesis details were available for the Canadian PFA cohort.

Survivorship of PFA, Reasons for, and Types of Revisions

The risk of all-cause revision was high in all eight registries surveyed. At 2 years, the CPRs were 2.9% (95% CI 1.3 to 4.5) for New Zealand, 2.2% (95% CI 0.6 to 3.7) for Norway, and 3.0% (95% CI 1.5 to 4.6) for Sweden. The 2-year CPRs for Australia, Kaiser Permanente, and Canada were 4.1% (95% CI 3.4 to 4.8), 4.1% (95% CI 2.0 to 6.2), and 4.6% (95% CI 2.1 to 7.2), respectively, followed by 5.6% (95% CI 4.2 to 7.0) for the Netherlands and 8.9% (95% CI 1.4 to 16.4) for Finland. By 6 years, the CPR was 25.8% (95% CI 4.5 to 47.2) and 20.4% (95% CI 17.5 to 23.2) for Finland and the Netherlands, respectively. Kaiser Permanente and Australia had similar 6-year CPRs of 14.9% (95% CI 10.1 to 19.7) and 15.9% (95% CI 14.5 to 17.4), respectively, while the lowest CPRs were 10.8% (95% CI 7.4 to 14.3) for Sweden, 10% (95% CI 6.4 to 13.4) for New Zealand, and 9.2% (95% CI 5.3 to 13.1) for Norway. At 10 years, Australia had a CPR of

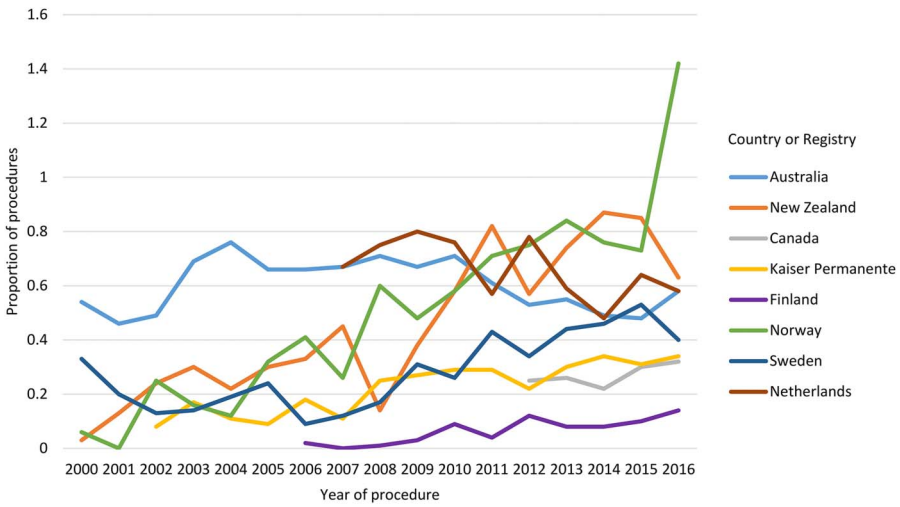

Fig. 1 This graph shows the proportion of primary patellofemoral arthroplasty procedures per year by country or registry.

Table 1. Primary patellofemoral arthroplasty by year of procedure and country or registry (2000 to 2016)

Procedure year	Australia n = 3282	New Zealand n = 466	Canada n = 431	Kaiser Permanente n = 419	Finland n = 76	Norway n = 359	Sweden n = 517	Netherlands n = 1234
2000	23	1				1	17	
2001	58	4				0	12	
2002	96	7		2		5	9	
2003	151	9		7		4	10	
2004	180	9		6		3	16	
2005	174	17		6		9	21	
2006	181	17		14	2	11	9	
2007	195	26		10	0	8	12	47
2008	232	8		24	1	21	17	88
2009	229	23		27	3	19	37	134
2010	268	35		35	9	23	31	141
2011	247	51		38	4	29	52	111
2012	225	36	70	30	13	33	43	168
2013	246	49	80	44	9	38	56	132
2014	234	64	71	57	8	38	58	116
2015	243	61	98	54	10	39	65	154
2016	300	49	112	65	17	78	52	143

26.6% (95% CI 24.4 to 28.7), Sweden had a CPR of 22.1% (95% CI 15.5 to 28.7) and Norway had a CPR of 16.9% (95% CI 9.8 to 24.0) (Table 2).

Because the number of revisions in each of the registries was small, data on the reasons for revision and type of revision performed were amalgamated. Reasons for revision included disease progression, 42% (434 of 1034 of all revisions), ongoing pain, 17% (176 of 1034), implant loosening or lysis, 14% (146 of 1034), malalignment and mal-tracking, 6% (62 of 1034), patella implant breakage or wear, 5% (48 of 1034), instability or dislocation, 4% (41 of 1034), infection, 3% (31 of 1034), fracture, 1% (10 of 1034), with other or undocumented 9% (86) (Fig. 3). Some revisions had more than one reason documented.

In 98% (980 of 1001) of the combined registry data, the revision procedure was recorded. Revision to a TKA was performed in 83% (810 of 980) of the procedures; the patella only was revised in 10% (101 of 980) of procedures, patella and trochlea revision was performed in 5% (46 of 980), and other unicompartmental arthroplasty (tibiofemoral) was performed in 2% (15 of 980). Eight patients underwent two-stage revision for infection (1%), and in 21 patients, no data were available (Fig. 4).

Discussion

Patellofemoral arthroplasty is used for the treatment of isolated patellofemoral osteoarthritis, but as this form of knee osteoarthritis is relatively uncommon, there are limited data regarding the procedure and results. Therefore, we amalgamated data from one insurance-based and seven national registries to address this problem, to describe patient demographics and implant usage and survival, as well as the reasons for revision. The finding of greatest interest was the uniformly high short-term rate of revision for PFA in all eight registries surveyed, even with the predominant use of third-generation prostheses.

This study has several limitations. This study was restricted to demographic detail, prosthesis use, and overall survivorship. There may be aspects of PFA that have not been measured in this study, such as superior knee function or patient satisfaction compared with TKA. However, these potential advantages may not counter-balance the high revision rates shown [38]. Registry-calculated survivorship may underestimate the true failure rates, as some patients with poorly performing prostheses may elect not to or be too unwell to undergo revision surgery. As patients undergoing PFA are generally younger than patients undergoing TKA, the number of patients with failing PFA in this category would most likely be small. Registry-derived revision data may also suffer from the occasional difficulty matching primaries to revision procedures, missing data when implants are removed and not revised [10], and because of migration away from the region. For these reasons, registry data may overestimate the true survivorship. However, although it is likely to be an overestimate, the survivorship calculated from registries where almost all procedures are included would more accurately reflect revision rate than the rates calculated from selected case series. When comparing revision rates of PFA with TKA, some caution must be used,

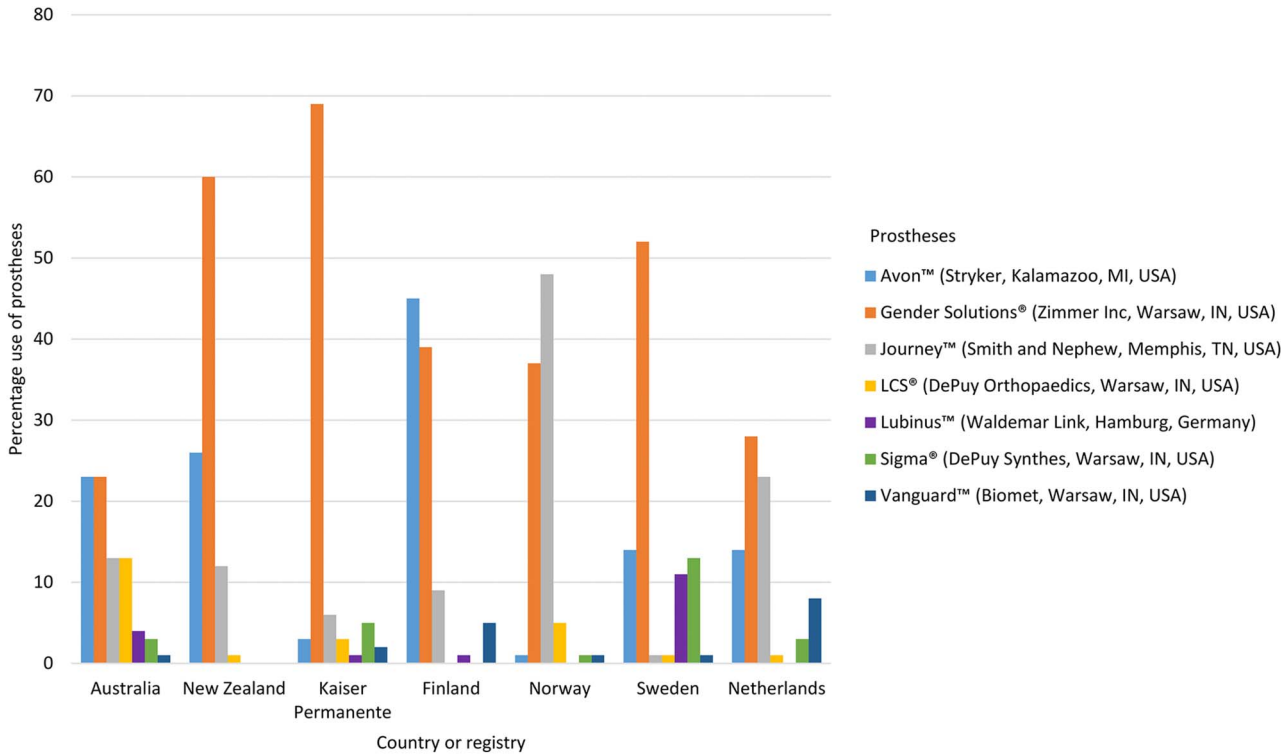

Fig. 2 This graph shows the percentage of prostheses used in primary patellofemoral arthroplasty by prosthesis name and country or registry.

as both patients and surgeons may have a lower threshold for undertaking a revision of a partial replacement due to the perceived lower morbidity. However, this concept would be unlikely to entirely explain a greater than threefold difference. Although we showed uniformity in patient demographics and usage rates for primary PFA, there may be variations between countries with regard to surgeon experience, patient selection, revision threshold, as well as waiting times and facilities for reoperation, which may differentially affect revision rates. These factors may explain some of the differences in CPR for the countries studied. The fact that PFA is uncommon may limit surgeon experience, perhaps leading to less reproducibility of the procedure and raising revision rates. However, revision rates determined by registry data would be a more accurate reflection of community practice than case studies performed by surgeons with a subspecialty interest in the procedure. We were unable to amalgamate data for a combined overall CPR or for individual prostheses because data are recorded differently and prosthesis use also varied between countries and multiple and different implant combinations were used. Although an overall CPR was not possible, we were able to obtain the CPR for each registry, which showed uniformly high rates of revision, so we feel this allows a global perspective. This limited approach does not aid in detecting poorer performing prostheses within this group, and this may be a possible future study.

Usage of Patellofemoral Arthroplasty

We found that PFA use was uncommon in the eight registries we studied, representing less than 1% of knee replacements from the study period. Still, this resulted in nearly 7000 such procedures being tracked during this study period, which is a considerable number for an approach that is relatively unproven. Previous metanalytic approaches have only gathered less than half of this number [23, 44]. Although the PFA proportion of knee replacements varied slightly, in all cases the use of PFA was lower than 1.2% of knee replacement reported by the National Joint Registry of England, Wales, Northern Ireland and the Isle of Man [30]. We feel the consistently low usage across the registries studied not only confirms the rarity of isolated patellofemoral arthritis but also reflects a similar level of surgeon acceptance of this procedure [45].

Patient and Prosthesis Characteristics Associated with PFA

In general, patients undergoing PFA were younger than those having TKA, more likely to be women than men, and in the pre-obese BMI class. We found the demographics of patients were generally comparable across the eight registries, with these findings also similar to other reports [23, 28, 46].

Table 2. Cumulative percent revision of primary patellofemoral arthroplasty by country or registry

Country/ registry	Number revised	Total	1 year, % (95% CI)	2 years, % (95% CI)	5 years, % (95% CI)	6 years, % (95% CI)	8 years, % (95% CI)	9 years, % (95% CI)	10 years, % (95% CI)	11 years, % (95% CI)
Australia	601	3282	0.8 (0.5 to 1.1)	4.1 (3.4 to 4.8)	13.2 (11.8 to 14.5)	15.9 (14.5 to 17.4)	21.7 (19.9 to 23.5)	24.0 (22.1 to 26.0)	26.6 (24.4 to 28.7)	29.4 (27.0 to 31.7)
New Zealand	44	466	0.7 (0.0 to 1.4)	2.9 (1.3 to 4.5)	8.7 (5.6 to 11.8)	9.9 (6.4 to 13.4)	16.4 (10.7 to 22.1)	18.9 (12.4 to 25.5)		
Canada	24	431	1.8 (0.4 to 3.1)	4.6 (2.1 to 7.2)						
Kaiser Permanente	41	419	0.8 (0.0 to 1.7)	4.1 (2.0 to 6.2)	12.6 (8.4 to 16.9)	14.9 (10.1 to 19.7)				
Finland	11	76	5.7 (0.0 to 11.4)	8.9 (1.4 to 16.4)	15.7 (4.1 to 27.2)	25.8 (4.5 to 47.2)				
Norway[a]	37	443	0.2 (0.0 to 0.7)	2.2 (0.6 to 3.7)	8.0 (4.5 to 11.5)	9.2 (5.3 to 13.1)	15.7 (9.2 to 22.2)	16.9 (9.8 to 24.0)	16.9 (9.8 to 24.0)	
Sweden	56	517	0.2 (0.0 to 0.6)	3.0 (1.5 to 4.6)	9.1 (6.0 to 12.1)	10.8 (7.4 to 14.3)	15.1 (10.4 to 19.8)	20.9 (14.6 to 27.2)	22.1 (15.5 to 28.7)	27.2 (19.3 to 35.0)
Netherlands[b]	187	1228	0.7 (0.2 to 1.1)	5.6 (4.2 to 7.0)	18.1 (15.5 to 20.7)	20.4 (17.5 to 23.2)	24.4 (20.7 to 28.0)			

[a]Additional procedures from 2017 were included in the survival estimates from Norway.
[b]Six procedures from the Netherlands were excluded from survival analysis.

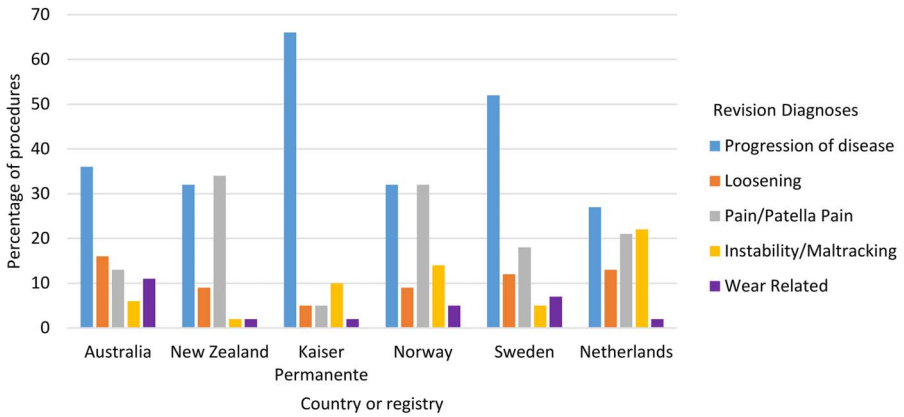

Fig. 3 This graph shows revision diagnoses of primary patellofemoral arthroplasty procedures by country or registry.

Osteoarthritis was the most frequent diagnosis. Some authors have reported lower revision rates when the primary pathology was trochlear dysplasia [3, 30]. Unfortunately, registry diagnosis records are not sufficiently granular to subclassify underlying reasons for osteoarthritis, such as trochlear dysplasia or patellar malalignment. Although there were inter-registry variations of the protheses used, 97% of the recorded prostheses were third-generation designs, which we feel represents current practice.

Survivorship of PFA, Reasons for, and Types of Revisions

In the eight registries we studied, PFA survivorship could only be characterized as poor, with 2-year CPR risk ranging from more than 4% to nearly 9% in these registries, and the 10-year revision risk exceeding 20% in two large national registries. The PFA revision risk is similar to that seen with large-head metal-on-metal conventional hip replacement; a finding that contributed to abandonment of that procedure and withdrawal of that bearing style [5]. This contrasts to the finding for TKA survivorship from registries, which is less than 3% at 2 years and less than 6% at 10 years [4, 28, 42]. The high proportion of revisions for disease progression and persistent pain (61%) after PFA suggest that appropriate patient selection for this procedure may be of greater importance than implantation technique or prosthesis durability. This aspect has also been highlighted by others [23, 46]. When a PFA was revised, in 83% TKA conversion was the revision procedure. Previous reports of PFA revision also show this, while also highlighting that revision is usually

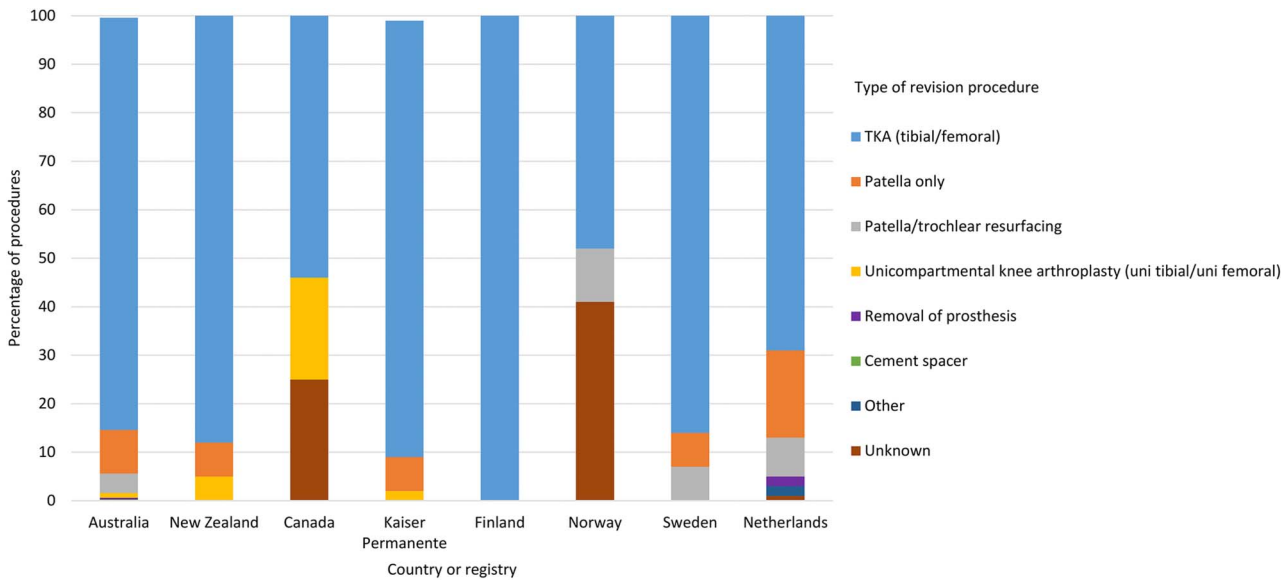

Fig. 4 This graph shows the type of revision of patellofemoral arthroplasty procedures by country or registry.

possible with primary total knee components and the use of stems or augments is infrequent [8, 14, 21, 22, 27, 32]. The poor survivorship of the TKA used to revise a PFA has been previously reported [21]. It had been our intention to compare PFA prosthesis performance, but this proved too difficult as the nomenclature of the components varied between countries, and the use of aggregate data did not allow for calculation of individual prosthesis survival.

Future collaboration between registries would be useful for analyzing other procedures that are not frequently performed, but to allow this to occur, registries must work closely to align data collection and sharing practices [12]. The International Prosthesis Library (IPL), which was jointly created by the International Society of Arthroplasty Registries (ISAR) and the orthopaedic industry (and is currently hosted by the American Joint Replacement Registry), provides information regarding attributes and description of orthopaedic devices, and this resource may help unify prosthesis classification and aid future multi-registry studies [37]. However, collaborations to combine data from registries create a new set of challenges including data protection, patient privacy, and consent issues [20, 34, 35].

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